A Study of the Structure of the Skin and Pubescence of the Peach in Relation to Brushing

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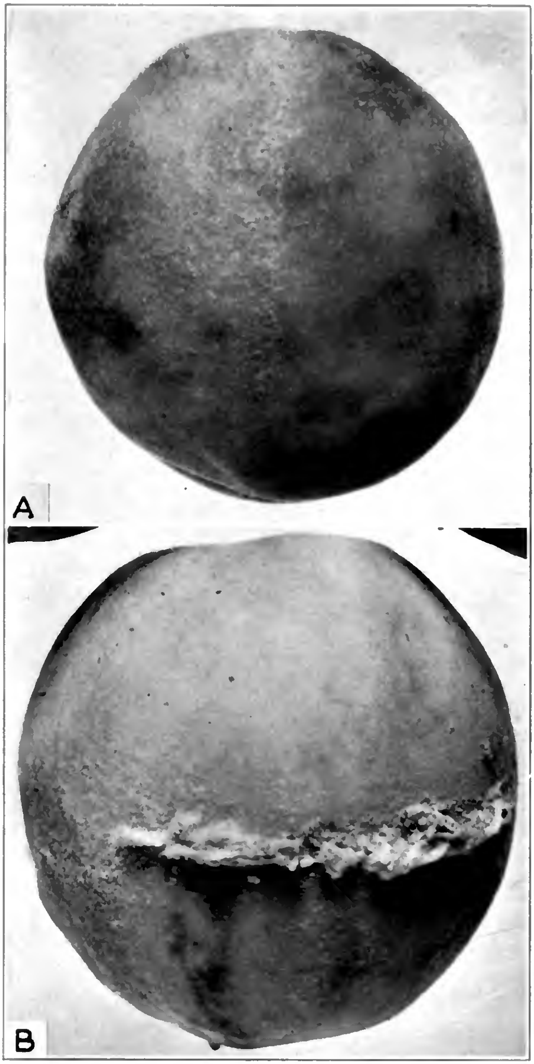

(A) Difference in Appearance Between the Brushed and Unbrushed Halves of an Elberta Peach. (B) The Pubescence Toward the Center on a Typical Elberta. The Surface Is Still Thickly Covered With the Shorter Hairs Even After Scraping.

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A Study of the Structure of the Skin and Pubescence of the Peach in Relation to Brushing

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THE SURFACE of the peach is thickly covered with hairs which, collectively, are referred to as pubescence or simply as "fuzz." Some varieties are so "fuzzy" that an otherwise attractive color is more or less masked or concealed. This is especially true of the smaller sizes of the more pubescent varieties. In order to "brighten" or improve the appearance of the fruit, brushing by various methods has been tried from time to time. The contrast between J. H. Hale, a "smooth" peach, and some of the more pubescent commercial varieties suggested this procedure several years ago.

More recently, however, since dusting with sulfur late in the season to control brown rot has become the usual practice, attention has again centered upon the fuzz because of the extent to which it holds spray material. The dulling effect of both excessive pubescence and spray residue upon the appearance of the fruit runs counter to an insistent demand in the trade for a cleaner, more attractive pack. To meet this demand, brushing machines of various types have come into use. Naturally, therefore, the addition of brushing to the packing shed operations raises the question as to its effect upon the shipping or keeping qualities of the fruit. It was the object of this investigation to study the situation in detail in order to answer this question.

REVIEW OF LITERATURE

Interest in the pubescence of the peach was probably first aroused by the contrast between the peach and the nectarine. Pomologists generally classify the nectarine as a hairless peach. In discussing the relationship between the peach and the nectarine, Darwin[3*] says: "We have excellent evidence of peach-stones producing nectarine trees, and of nectarine-stones producing peach trees—of the same tree bearing peaches and nectarines—of peach trees suddenly producing by bud-variation nectarines (such nectarines reproducing nectarines by seed),

*These figures refer to literature citations, page 424.

as well as fruit in part nectarine and in part peach—and, lastly, of one nectarine-tree first bearing half-and-half fruit, and subsequently true peaches."

In addition to the contrast between the pubescence of the peach and the nectarine, growers recognize differences between varieties. J. H. Hale, for instance, is known as a "smooth" peach and much of its attractiveness is due to the relatively slight coating of fuzz. Considering J. H. Hale as one extreme and varieties like Slappy or Lemon Free as the other, Elberta would be classified as moderately pubescent.

In "The Peaches of New York" (Hedrick and others[4*]), pubescence has been described in some detail in the principal varieties, such terms being used as coarse or fine, long or short, thick, thin, or scant. The pubescence of J. H. Hale is described as "light" and that of Elberta as "thick and coarse." A more critical study of this character in the different varieties might extend its taxonomic usefulness.

Curtis[2*] has outlined some of the main features of the epidermis of the peach, apricot, and nectarine in studying the way the brown rot fungus enters the surface of the stone fruits. In discussing the peach hair, she says, "The real weakness of the peach skin lies in its hairs, as most growers recognize without knowing the reason. The hair is a long narrow cylinder with an excessively thick wall and a narrow protoplasmic core extending from one end to the other. It is simply a single epidermal cell of unusual form and is inserted at the same level as the normal epidermal cell. The part at the base, lying between the adjoining epidermal cells, is narrower than the free upper part and forms a slender stalk. Two to five epidermal cells usually lie between any two hairs, but occasionally the interval is greater and less often it is smaller. At times also several hairs, even to half a dozen, may stand side by side without any epidermal cells between them. The insertion of two or more hairs into one socket may also be seen here and there."[a]

Curtis also gave some attention to the differences in skin structure between peach varieties as well as between the peach, nectarine, and apricot. Different varieties of the peach were found to vary in the number of hairs and in the "cushion-like" group of cells between the hairs which form rather acute "dips" toward them. This latter characteristic of the peach surface was found to have an important bearing upon the greater frequency of infection by the brown rot fungus by

[a]The use of the term socket in this connection is not strictly correct because the term implies an opening into which something is fitted. It is, however, a convenient description of the structures involved, since the restricted base of the hair appears to be fitted into the epidermal cell from which it is an outgrowth.

way of the hair rather than thru the stomata or the epidermis direct. Emphasis was placed upon the very large, square, firm-walled cells with a thick cuticle in the Early Rivers and Goldmine nectarines, but hairs were not mentioned as occurring in these varieties, which were apparently mature when examined. Stomata, however, were relatively numerous in the nectarine.

In the apricots studied by Curtis, the hairs were fewer than in the peach, the average number of epidermal cells between hairs in Moorpark being twenty-one. The hairs of the apricot were found to be narrower, with thinner walls, and a wider protoplasmic cavity.

More recently, in studying the chemical composition and the histological structure of the peach flesh, Addoms, Nightingale, and Blake[1*] described the transitional stages in the formation of the skin in some detail. The structure of the cell layers in the skin at different times thruout the season, as well as the changes which take place toward maturity, was described. The growth stages under Illinois conditions were also worked out in this study, and drawings were made of them before the above publication appeared. Since, in the New Jersey studies, more stress is placed upon the chemical changes than upon the structure of the skin and pubescence, some duplication is purposely included here in order to present more accurately the intimate relationship between the peach skin and the pubescence.

STUDIES OF THE SURFACE OF THE PEACH

The Peach Skin

A histological study of the skin at different stages of growth seemed advisable because in this way it would be possible to arrive at a clearer understanding of its structure as found at maturity. To this end, the first material was collected in December, when, in Illinois, the peach shows the lowest vegetative activity of any time during the dormant season.

Early Stages.—In the rudimentary pistil at the end of the growing season the cells of the epidermis are undifferentiated and of about the same size as those in the layers immediately beneath. The epidermal cells appear somewhat compressed, with the radial diameter in some instances as much as twice that of the transverse diameter. The shape of these cells does not change much during the relatively slight growth which takes place in midwinter. With the more active growth in the fruit bud, which, in Illinois, starts in February or March, the epidermal cells soon form a distinct layer, in which the radial diameter is generally nearly twice as long as it was in early winter (Fig. 1: A, B, C).

FIG. 1

(A) Captain Ede, showing the epidermal cells at the initiation of hair formation, March 19 (1927). Note the long radial diameter of the epidermal cells at this date and the bulge in the hair cell at the surface of the pistil. × 370

(B) Elberta. The general proportions of the epidermal cells on March 17 (1926) in material collected at Anna, Illinois. × 370

(C) Gage. The general proportions of the epidermal cells on February 26, 1928, before the initial stages of hair formation. × 370

(D) J. H. Hale. A tangential section thru the skin of a ripe fruit. The sockets and the cellulose deposit in the hair cell at the base are shown. Note the hyaline area between the cell wall and the cellulose deposit. The lateral stretching of the cells between the hairs can be seen in this drawing. × 180

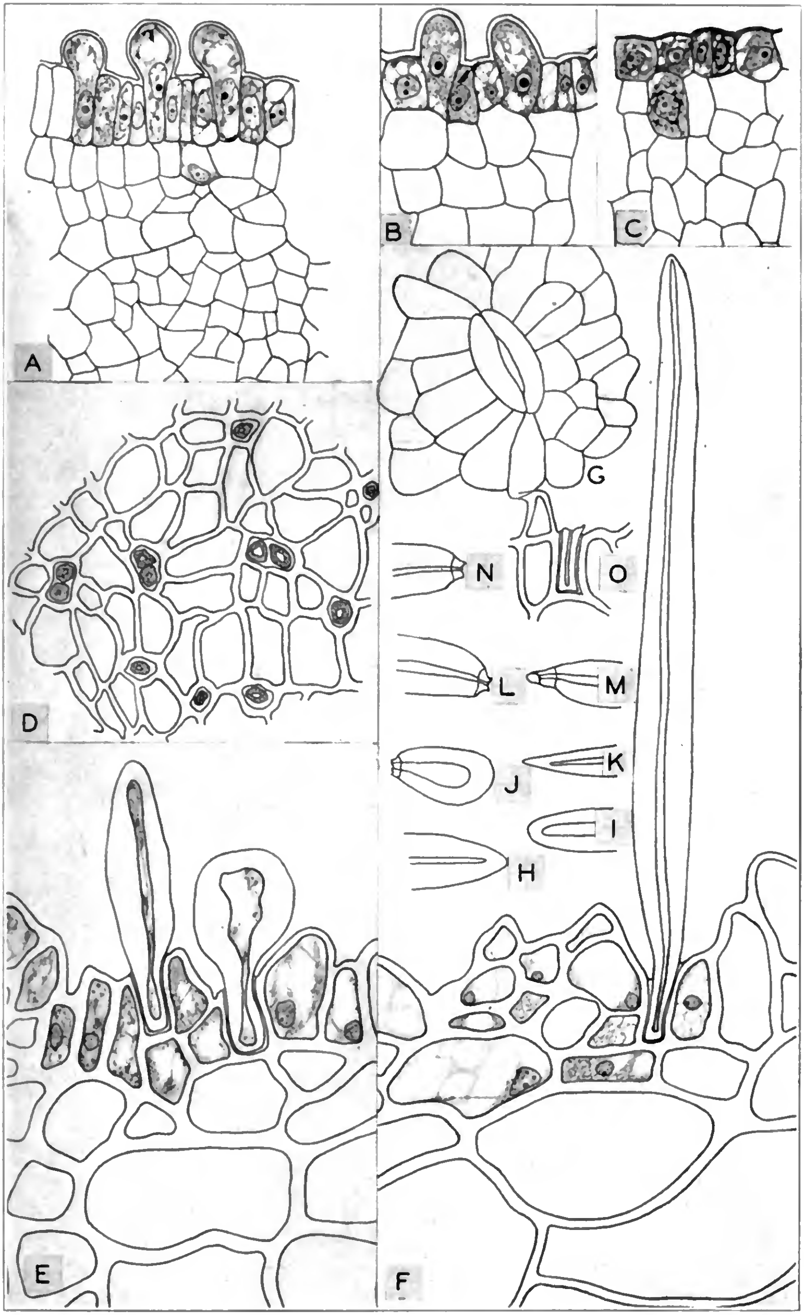
(E) A section of the skin of Elberta, showing the buffer cells and the round-pointed short hairs. × 370

(F) A hair of medium length. Observe the central cylinder, the insertion at the base, and the buffer cells of the skin. Note the size of the cells at maturity as compared with the earlier stages in March (B). × 180

(G) A stomata of Elberta. × 180 See also Fig. 3, page 416.

(H, I, K) Hairs of Elberta from a packing shed sample, showing the variation in the sharpness of the point. × 370

(J, L, M, N, O) The appearance of the broken surface of the hair at the base.


A
B
C
D
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These dimensions are interesting because as early as March the outer wall of an occasional cell begins to bulge out in the first stages of hair formation. The radial length of the epidermal cells at this time determines the general proportions of the base of the hair.

At bloom the epidermal cells have grown in length so that many of them are two or three times as long as wide and about twice as long as they were in March. The cells underneath have not changed much in shape or appearance with the increase in size which has taken place in the base of the pistil at bloom.

Changes Following Fertilization.—In the stimulus to growth which comes from fertilization, further differentiation soon becomes apparent both in the epidermis and in the cells beneath. The cytoplasm in the epidermal cells becomes denser and the outer wall increases noticeably in thickness. The three- to five-cell layers beneath the epidermis have about the same shape as the cells still deeper. At shuck fall, however, for the first time the cells beneath the epidermis show some lateral stretching.

By the time of the June drop the hypodermal layers have grown still more as compared with the dimensions at shuck fall, and the layers six or seven cells deep now show some lateral elongation. This stretching of the outer cells continues with the further increase in the size of the fruit, and cells as deep as ten layers from the surface appear slightly oval in outline when the stone is hardening at the tip. The walls of the hypodermal cells are noticeably thicker and are small and compact in comparison with the large spherical cells of the flesh.

The Peach Skin at Maturity.—In Elberta, at the beginning of the third month after bloom, the skin has the characteristic structure found at maturity. The radial diameter of the epidermal cells, which earlier in the season corresponded closely to the dimensions of the socket, has by this time increased as much as three times the original depth. The hair at the base has a common wall with three to five of the epidermal cells but does not stretch laterally as the fruit grows, the adjustment to the increase in the size of the fruit being made entirely by the lateral stretching of the surrounding cells. The extent of this adjustment can be seen in Fig. 1, D.

Thus in the growth of the fruit, the epidermal cells pass thru three fairly distinct stages. During the period of hair formation they are quite regular in size and arrangement and are longest in the radial diameter. Following this period, as the fruit enlarges, they undergo considerable lateral stretching. Then, in the final swell they become very irregular in size, and instead of being arranged in regular rows in the plane of the surface of the fruit, they push outward between the hairs, assuming a variety of forms. (Fig. 1, E and F). It would seem that, in going thru these changes, the epidermal cells, and to some extent those immediately beneath, have become buffer cells, and that the tensile strength of the skin depends more and more upon the deeper layers which show such pronounced lateral stretching (Fig. 2). This piling up of the buffer, or "cushion," cells has been noted by Curtis[2*] in a study of brown rot (*Sclerotinia cinerea*) infection.

In the mature peach the skin is composed of a number of cell layers. These are shown in Fig. 2 for a number of varieties. As the fruit ripens, the cell walls of the outer flesh become thinner and the protopectin content of the cell walls less (Addoms, Nightingale, and Blake[1*]). As this process continues, the walls of the inner skin are affected in the same way and, as a result, the outer, stronger or more adherent layers can be peeled off. Studies of the skin thus separated from soft ripe fruit show fewer cell layers than would be included in it from a study of the photomicrographs in Fig. 2.

The strength of the skin is also affected by the ripening processes. Fruit of Elberta ripe enough for the skin to peel tested three to three and one-half pounds. When the skin of a "dead ripe" Elberta is peeled off, stretched across the opening of a vial (½ inch in diameter), and its strength tested with a pressure tester, it offers only one and one-half pounds resistance. Two factors, therefore, affect the firmness of the peach: the tensile strength of the skin, and the support afforded the skin by the cells of the flesh beneath. Greater demands are made upon the tensile, or bridging, strength of the skin proper as the fruit approaches the soft ripe stage because of the thinner walls, or the separation of the flesh cells by the dissolution of the middle lamella.

In this connection mention should be made of the stomata in the peach skin. They can be located easily in the mature fruit without a lens, because there is an area about them two to four cells back from the guard cells in which there is no pubescence. These areas can be seen in Fig. 3. The guard cells are very large (Fig. 1, G) and, as with the socket cells, there is considerable lateral stretching in the cells adjacent to them. The position of the stomata is made conspicuous, especially against a yellowish background, by the coloring pigment in the cells immediately beneath. As far as could be determined from a microscopic examination of brushed peaches, the stomatal area did not appear to be injured. The shorter hairs adjacent to the stomata would no doubt furnish some protection from the brushes.

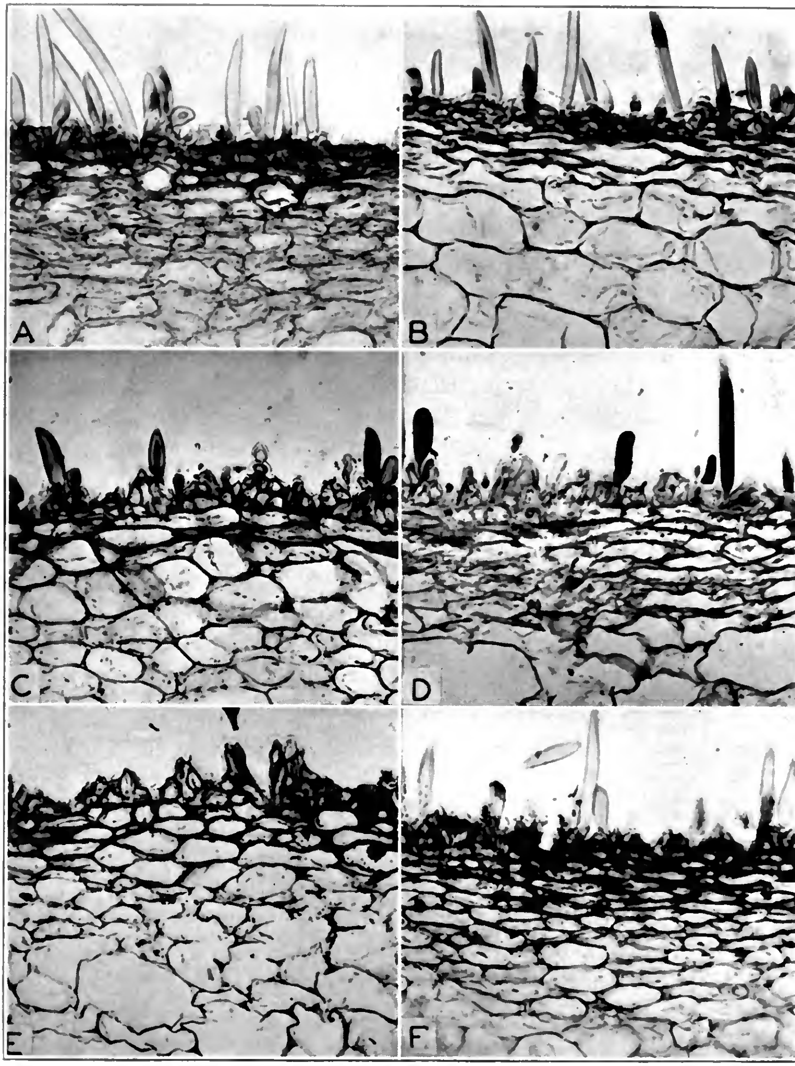

FIG. 2.—SECTIONS OF RIPE PEACHES SHOWING THE GENERAL PROPORTIONS OF THE CELLS OF THE SKIN AND SHORTER HAIRS

(A) Belle; note number of shorter hairs. (B) The large flesh cells and extended skin cells of South Haven. (C, D) Elberta, showing the outer buffer cells of the skin. In C these had not yet been broken by brushing. (E) An extreme extension of the buffer cells in Wilma about a hair base. (F) The strong, compact skin of a small-fruited seedling peach.

The Peach Hair

As with the peach skin, the details of hair formation have been traced from the initial stages to maturity. With the transitional stages in mind, the intimate relationship between the pubescence and the skin, or epidermis, can best be understood.

Early Stages.—The rudimentary peach pistil is not pubescent in the fall and early winter. The first evidence of hair formation was found, under the conditions of growth in Illinois, in material collected in March. At this time the epidermal cells, as noted earlier, are long and narrow, and in the initial stages of hair formation the outer wall of cells here and there over the pistil grows outward in finger-like projections (Fig. 1: A, B, C). These are found at the base of the pistil first, then afterward farther along toward the stigma, none forming, however, on the distal one-quarter or so of the length of the style. While the first stages of hair formation occur as early as March, hairs continue to form in Elberta and J. H. Hale until about a month after bloom. The period of hair formation may be somewhat shorter than this, however, in some of the early varieties.

With the growth in early spring, hair formation proceeds so rapidly that as early as bloom the base of the pistil is densely pubescent. Sections of the fruit at this time show only two to four cells between the hairs. The large number of cells in the surface layer of the young fruit which form hairs and the bulge of the hair at the surface account for the density of the pubescence. All of the first hairs to form seem to grow to full length.

In the growing hair the stainable cytoplasm is thin, flocculent, and evenly distributed (Fig. 1, A). The nucleus migrates from its original position in the cell and is found centrally located in the elongating hair. In the young fruit the hair wall is thin and quite regular in outline. The shape of the hair in the initial stages is oval or oblong, with a pronounced bulge at the base. As the hair lengthens, it becomes more pointed, the longer hairs being quite sharp by the time they have reached full length (Fig. 1, H and K). During the first period of growth in the fruit the hairs appear very close together, but as the fruit increases in size they are separated farther and farther as a result of the lateral stretching of the cells between (Fig. 1, D).

Intermediate Stages.—Near the end of the first period of growth of fruit, which in Elberta is a month or so after bloom, two significant things take place: first, the cells in the surface tissues of the peach stop dividing and, second, the period during which new hairs are formed comes to an end. The latter process closely follows the first.

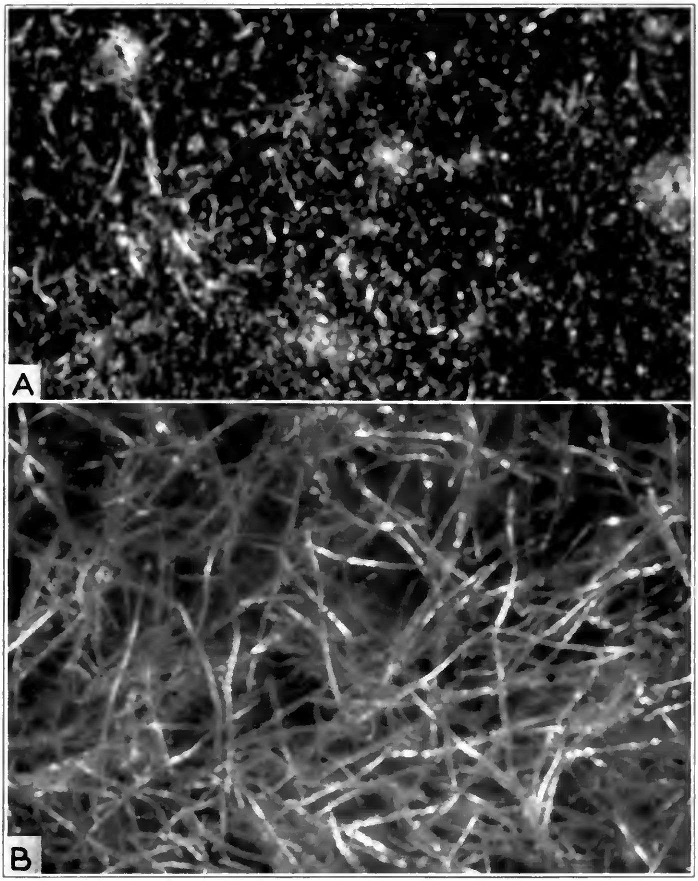

FIG. 3.—BRUSHED AND UNBRUSHED SURFACES OF ELBERTA MAGNIFIED ABOUT THIRTY TIMES

The stomata and short hairs are to be seen in A. The long, tangled hairs shown in B were nearly all taken off by the brushing.

This relationship has been carefully checked in material collected during three crop years. The time of the cessation of cell division first observed in material collected in 1927 corresponds closely to the findings of Addoms, Nightingale, and Blake.[1*]

Up until three weeks or so after bloom the long hairs seem to be more numerous. During the first period of growth, however, as the stand of the longer hairs is gradually thinned by the expansion of the fruit, the spaces between them are filled by the formation of an immense number of the shorter hairs. This relationship between the shorter and longer hairs remains the same from the midperiod on because no new hairs are formed subsequent to the initiation of the thickening of the hair wall.

In the walls of the longer hairs the thickening process starts about ten days after bloom, and is completed by the end of the first period of growth. A few days later the process starts in the shorter hairs, which are formed last, and is nearly completed by the time the stones start to harden at the tip. When the deposition of cellulose starts in the hair wall there is no further elongation, and the shape of the individual hairs at the time—that is, globular in the very youngest, and oval, oblong, or long-pointed in the oldest—is retained (Fig. 1, E).

As the cellulose layer becomes thicker, the cytoplasm in the hair is gradually compressed. The nucleus, which is so conspicuous earlier in the season, becomes less and less distinct, until finally it can no longer be detected in the cytoplasm (Fig. 1, E and F). Since the thickening takes place by the deposition of material from within, there is no increase in the diameter of the hair. Intermediate stages in the deposition of material in the wall can be observed best in hairs of different ages about the first week in May.

The Mature Peach Hair.—Hairs taken from ripe fruit have, to all appearances, the same shape as earlier in the season. Something of these extremes in size and shape are shown in Fig. 4. Earlier in the season the predominance of the longer hairs was emphasized but in the ripe fruit the shorter types may be more numerous.

The final growth-changes greatly compress the cytoplasmic content of the tube-like opening in the hairs. In some of the longer hairs there appear to be partitions in the tube, but generally there is no such interruption (Fig. 1, F). In the samples examined from the different varieties, most of the hairs were more or less curved but some were decidedly crooked. The diameter of the individual hairs was found to be variable, some of the larger ones being four or more times the thickness of others.

Microchemical tests have been made to determine the composition of the mature hairs of a number of varieties. These tests show that the material deposited in the thickening process is cellulose, the tests for callose, chitin, and lignin all being negative. The compressed material in the core of the mature hair gave a positive reaction for protoplasm with methylane blue, gentian violet, and carmen.

It should be stated at this point that the epidermal cells have been studied in four varieties of the nectarine to determine whether or not hairs are found as in the peach. On pistils of Lippincotts Late

Orange and Goldmine nectarine, collected at the New Jersey Station,[a] March 24, 1927, there was no evidence of hair formation. In the peach it will be recalled that the initial stages of hair formation were found in March. In young fruits of Boston and Victoria varieties, collected at the New York (Geneva) Agricultural Experiment Station ten days

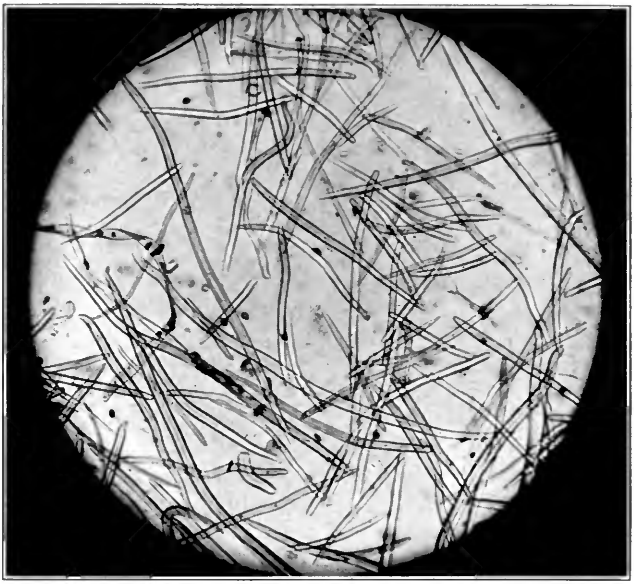

FIG. 4.—MICROPHOTOGRAPH OF HAIRS REMOVED FROM ELBERTA BY A BRUSHING MACHINE

Note the dirt or spray particles taken off with the fuzz. The variation in the length and diameter of the hairs is evident. Observe, also, the absence of short, round-pointed hairs in this debris from the brushing machine.

after bloom, there was still no evidence of hair cells. There were giant cells in the epidermis of these varieties which projected beyond the plane of the epidermis, but there were no hairs. It would seem, therefore, that the nectarine is, strictly speaking, a hairless peach.

EFFECT OF BRUSHING

With the structure of the peach skin and hair as presented in the preceding sections of this report in mind, an attempt can now be made to evaluate the effect of the brushing process upon the fruit. It would

[a]The writers are indebted to C. H. Connors, of the New Jersey Station, and to R. Wellington, of the New York State Station, for the nectarine material.

seem that the most direct approach to the problem would be thru an examination of the skin and hair to see what has happened to them in going over the brushes.

Effect of Brushing on the Skin.—A large number of individual fruits taken from the conveyor immediately after coming thru the brushing machine were examined. Care was taken to note any injuries or punctures before the fruit entered the machine, in order to make a sharp distinction between injuries directly attributable to the brushes and those due to other factors. From these studies it was quite evident that the brushing operation seldom injured the surface of a hard ripe fruit. Occasionally the skin was broken on soft ripe specimens, but these breaks could be attributed to the rubbing or crowding against other fruits as well as to the brushes.

As noted previously, the stomatal area did not prove to be a weak spot in the skin, even tho it may seem that hairs from the brushes might cause punctures at this point. It may be stated, therefore, that other causes such as "stem pulls," limb or basket punctures, or even fingernail scratches (Lloyd and Newell[5*]) are by far more serious than breaks in the skin from the brushes. The histological studies of brushed and even scraped fruit confirm these observations. The projecting buffer cells are strong enough and are sufficiently protected by the shorter hairs so that they are not injured by brushing or other treatments which do not break the skin (Fig. 2).

Effect of Brushing on the Peach Hair.—A microscopic examination was made of a large number of hairs taken from mature fruit in different ways in order to determine just what happens when they are broken off. Before the histological studies were completed, an attempt was made to pull out individual hairs. When it was found that this could not be done without breaking them at the base, a study was made of samples of fuzz collected from different sheds where the "dust" from the brushing machine was allowed to settle. Microscopic examination of thousands of individual hairs taken at random from these samples showed three significant things. First, the hairs had been broken off at the base, i.e., at the surface of the fruit; not a single instance was found in which the base of the hair was pulled out of the epidermis unbroken. Second, in the samples taken from the brushing sheds the longer hairs were by far the more numerous; in fact, while many of the intermediate lengths were broken off in brushing, practically none of the stubs (Fig. 1, E) were found to have been removed. Third, the individual hairs so uniformly broken off at the base were seldom broken at other points. As would be expected, quantities of dirt, dust, spray material, occasional spores and pollen were found in the refuse from the brushes (Fig. 4).

The question which now arises is: Why are peach hairs so uniformly broken off at the base instead of being pulled out?

In the discussion of the initial stages of hair cells emphasis was placed upon the narrowness of the socket which constitutes the inserted part and also upon the bulge, or flaring out, of the hair at the base immediately above the epidermis. These general proportions of the hair are not altered appreciably in subsequent growth changes. The size or diameter of the hair, then, may be looked upon as the first cause of weakness at the base (Fig. 1, A and F).

The next item of special interest in this connection is the thickening in the hair wall. Previous to the beginning of this process the wall is thin and, as a result, the hairs are soft and pliable. As the deposition of cellulose continues, the wall grows thicker and stronger and the hair, thus strengthened, becomes stiffer. The thickening of the wall takes place thruout its full length, including the inserted part, but, as may be seen from the drawings and photomicrographs, the dimensions of the hair at the base limit the extent to which the thickening of the wall can increase its strength at that point. The end result of the thickening process, therefore, is to accentuate the weakness of the hair at the base and, on account of the strength and stiffness thruout its length, bending and breaking must occur at the weakest point.

The third consideration tending toward greater weakness of the hair at the breaking point comes as a result of changes in the walls of the epidermal and hypodermal cells. The walls of these cells become stronger and thicker during the third period of growth, which is after the deposition of the cellulose layer in the interior of the hair. This extra strength in the socket cell offers still further resistance, or anchorage, to the hair because the socket has a common wall with the adjacent epidermal cells. If the wall of the projecting part of the hair increased in thickness and strength as does the inserted part, the hair would be strengthened at the base with the oncoming of maturity. But this is not the case. This differential in the strength of the hair in the plane of the outer surface of the epidermal cells falls in line with the other two characteristics of the base noted above. These three considerations, therefore, taken together, would seem to account, at least for the most part, for the manner in which the hair is broken in handling or in the brushing process.

These three factors just noted, however, do not account for the marked difference in the breaking strength of the longer and shorter hairs. While the longer hairs are easily broken off either by brushing or scraping, probably because of the greater leverage, the shorter ones can be removed only with difficulty, even by scraping. The structure at the base appears to be the same for all lengths, but the longer hairs are apparently more brittle. The difference in age between the longer and the shorter hairs may result in differences in strength which are not evident structurally. On account of the marked difference in the strength between the longer and the shorter hairs as maturity is approached, the protection of the surface depends more and more upon the buffer cells and the shorter hairs. In fact, toward the end of the

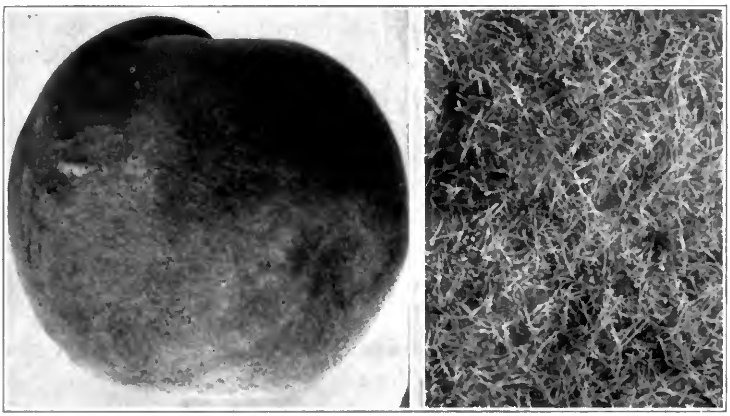

FIG. 6.—DENSE PUBESCENCE ON A SMALL ELBERTA PEACH
The photograph at the right shows the surface magnified about ten times.

season the longer hairs are rubbed off, or "weathered away," on many of the more exposed fruits. As long, however, as the longer hairs are held on the surface of the fruit by the shorter ones, they may be looked upon as still aiding in protecting the fruit.

The character of the surface left by the break in the hair at the base has also been examined. In some instances the break, or a part of it, seems to be slightly below the point of greatest restriction in the hair. In other cases the break is farther up. On account of the restriction in the hair at the base and the very small opening in the cellulose core, it would seem that there would be the least possible exposure to infection from breaking at this point. It remains to be seen whether germ tubes of spores actually enter the broken surface of the hair to a greater extent than thru the stomata or between the buffer cells and the stalk of the hair as noted by Curtis.[2*]

The brushing process, as such, is responsible for breaking only a part of the hairs on brushed fruit. Of the longer hairs broken in other ways, some are lost before going thru the machine and the others held on the surface by the short hairs are for the most part removed by the brushes. In so far as the breaking of the hairs may be looked upon as an injury, therefore, only a part of it can be laid to the brushing.

In the final analysis brushing must be evaluated in terms of the kind of surface left by the process. It is evident that changes due to brushing consist primarily in (a) the removal of the longer hairs, and (b) in the exposure of surfaces where the hairs were broken off (Fig. 1: J, L, M, N, O). Curtis[2]* makes no mention of the bearing of the breaking of the hairs at the base upon brown rot infection, but Smith[6]* found "nearly twice as much brown rot in the peaches which were brushed and undusted [with Koppers Thylox dusting sulfur] as there was in those which were unbrushed and undusted." These studies were made by Smith[6]* during the 1928 season, which was not a bad brown rot year.[a] During the 1931 season, however, growers had no trouble with brown rot on brushed peaches, even in distant shipments.

Finally, this study presents a clearer conception of the nature of the surface of the peach. Protection is furnished directly by both the pubescence and buffer cells. The strength of the skin depends upon the tensile strength of the hypodermal layers and upon the extent to which the ripening processes have advanced in the flesh cells and the deeper cells which may be considered as a part of the skin. In view of the protrusion of the buffer cells it would seem particularly fortunate, from the standpoint of brushing, that the shorter hairs, which are so difficult to break, are not sharply pointed. If this were the case, frequent punctures in the surface cells could be expected from this source after the longer hairs had been removed.

SUMMARY AND CONCLUSIONS

1. The excessive pubescence of some varieties and the spray-residue problem have stimulated interest in brushing peaches. Considering the nectarine as one extreme and some of the more pubescent varieties of peaches as the other, there is much variation in the amount of fuzz borne by this division of the drupe fruits. The apricot falls between the peach and nectarine in the amount of pubescence on the surface of the fruit.

[a]Smith's studies of the reason brushing tended to increase the susceptibility of peaches to brown rot is to be made in a separate report.

2. The changes which take place in the epidermis and the cell layers below, in the formation of the peach skin, were followed from the dormant bud to maturity. At first only the epidermal layer protects the young fruit, but as growth and enlargement proceed, the deeper layers function with the epidermis as a protecting layer to the fruit. At maturity the epidermal cells, and to some extent the one or two layers below, appear to function as buffer cells more than as cells contributing to the tensile strength of the skin, the latter function being assumed to a greater extent by the hypodermal layers.

3. The peach hair is an outgrowth from a single epidermal cell. The initial stages of the first hairs formed occur as early as March, but hairs continue to form in Elberta until about three weeks after bloom. The first hairs formed reach full length before the start of the deposition of a cellulose layer on the interior of the wall. With the initiation of this process, which occurs about the time the stone is hardening at the tip, further elongation stops in hairs of all lengths.

4. The peach hair is broken off at the surface of the fruit either in brushing or in handling. Three factors contribute to the weakness of the hair at this point. First, during the entire period over which hairs are formed, the epidermal cells are long and narrow thru the radial diameter. These proportions of the epidermal cells determine the size of the inserted base of the hair. The pronounced enlargement in the hair at the surface of the fruit limits its strength at the point of greatest restriction. In the second place, the deposition of cellulose on the interior of the hair wall would seem to strengthen the hair in proportion to the thickness of the layer. The restricted base limits the amount of the material deposited. The base of the hair thus restricted is relatively weaker after the thickening process is completed than before. Third, the cell walls of the skin become much thicker and stronger toward maturity and, consequently, strengthen the attachment of the hair at the base, the socket having a common wall with the adjacent epidermal cells. The end result of these three factors places the weakest point in the hair at its union with the surface, where it so uniformly breaks.

5. Since many of the hairs, especially the longer ones, are broken in handling or rubbing before going thru the machine, only a part of the breaking can be attributed directly to brushing. Brushing removes a much larger proportion of the longer hairs than the shorter ones. In fact, the very short hairs are seldom broken off and, consequently, are not found in the refuse from the brushing machines.

6. The experimental data available so far (Smith[6*]) indicate that brushed peaches are somewhat more susceptible to brown rot infection

than unbrushed peaches. The experience of growers, however, with brushing when brown rot is not serious shows that the gain from a cleaner, more attractive pack is greater than the loss from rotting.

7. Both the pubescence and the skin function in protecting the surface of the peach, the former thru the cushioning effect of the fuzz, and the latter thru the buffer cells of the epidermis and the lateral tensile strength of the deeper cell layers.

8. In practice, brushing would seem to be a safe procedure in so far as direct injury to the fruit is concerned. Since hairs are broken off at the base in handling as well as by brushing, only a part of the wounding that results from broken hairs can be attributed directly to brushing. It would seem logical, however, to suppose that spores could make a much more direct contact with a brushed surface than with an unbrushed surface.

LITERATURE CITED

1. ADDOMS, R. M., NIGHTINGALE, G. T., and BLAKE, M. A. Development and ripening of peaches as correlated with physical characteristics, chemical composition, and histological structure of the fruit flesh: II. Histology and microchemistry. N. J. Agr. Exp. Sta. Bul. 507. 1930.
2. CURTIS, K. M. The morphological aspect of resistance to brown rot in stone fruit. Ann. Bot. **42**, 39. 1928.
3. DARWIN, CHARLES. The variation of animals and plants under domestication. (Authorized edition, page 411.) New York, 1868.
4. HEDRICK, U. P., *et al.* The peaches of New York. N.Y. (Geneva) Agr. Exp. Sta. Ann. Rpt. 1916, Pt. II. 1917.
5. LLOYD, J. W. and NEWELL, H. M. Some factors influencing the keeping quality of fruit in transit. Ill. Agr. Exp. Sta. Bul. 350. 1930.
6. SMITH, M. A. Dusting peaches at the grader. Trans. Ill. Hort. Soc. **62**. 447. 1928.